Laboratory for Energy Conversion

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Status of ETH Zurich's Tin Droplet Dispenser for LPP Sources

Bob Rollinger, Andrea Giovannini, Davide Bleiner, Ndaona Chokani, and Reza S. Abhari

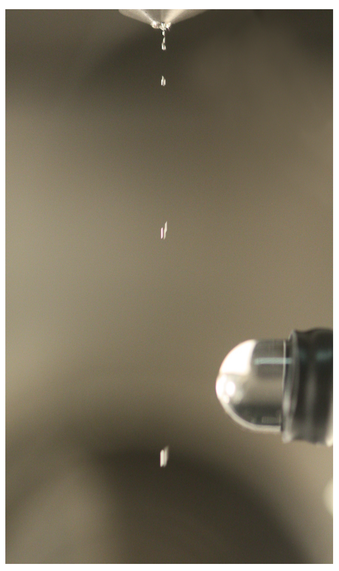
Extreme ultraviolet lithography (EUVL) based on Laser-Produced Plasma (LPP) sources requires tin droplet targets to be dispensed into the high vacuum environment. In the ETH facility, the EUV emitting plasma is obtained from tin droplets irradiated by a pulsed laser. Pure tin droplets are generated with an in-house developed droplet dispenser. The presented droplet dispenser is fulfilling the fuel source requirements for integration into a source collector module.

Tin droplet dispenser

The main requirements for the tin droplet dispenser are:
- Reproducible size
- Stable frequency
- Controllable speed

The key characteristics of the droplet dispenser are
- droplet repetition rates up to 10kHz
- interchangeable nozzles
- long-term operation by means of advanced thermal and fluid management
- long-term droplet train deflection compensation by active steering of dispensing unit
- use of pure tin (no additional contamination)
- protection against plasma debris and source heat load

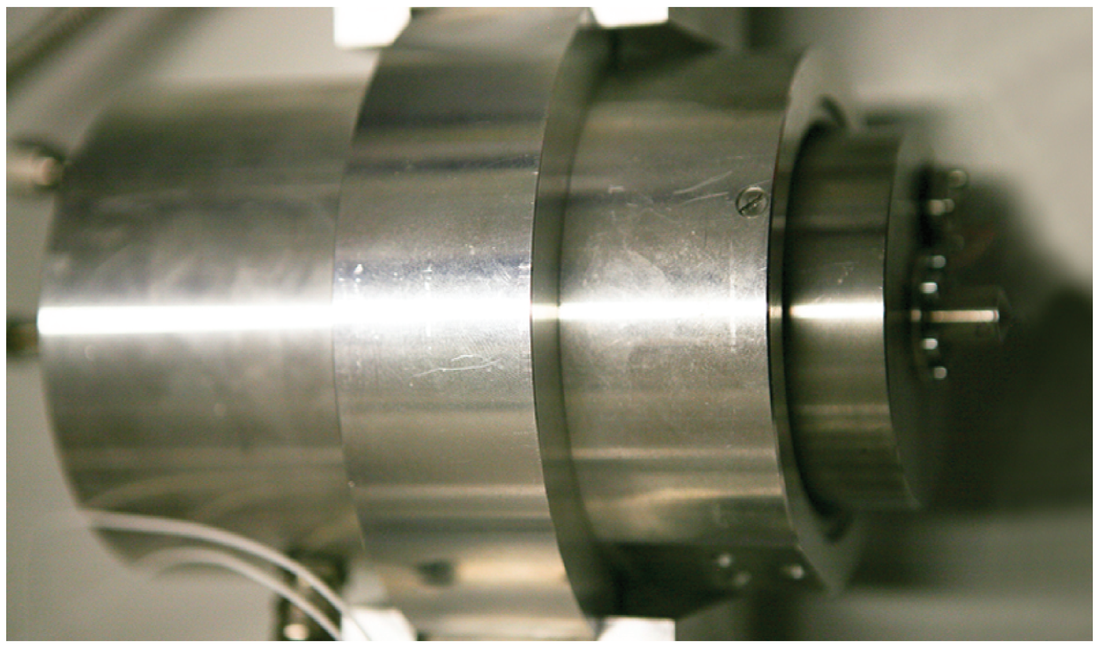
Operation



Once the initial heating is completed, the tin dispenser can be operated. The picture on the left shows tin droplets leaving the dispenser nozzle and falling into the vacuum chamber.:

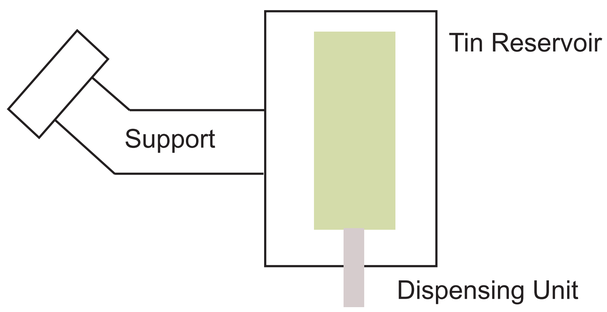
- Repetition rate can be varied from 200-10'000Hz.
- Back pressure and nozzle size determine droplet size
- Typical velocities at the target irradiation site are in the range of 10 m/s.

Velocity and droplet size can be controlled over a lange range by adjusting the back pressure of the tin reservoir.



Design

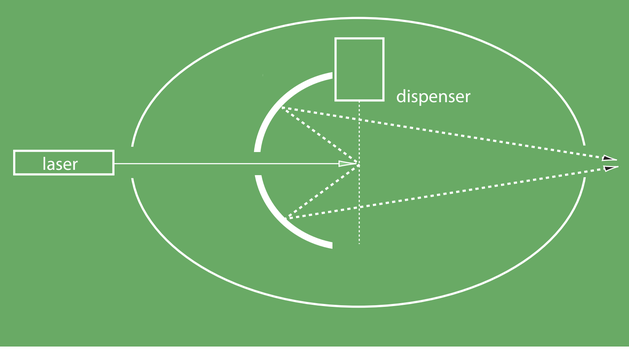
The tin droplet module comprises a droplet dispensing unit and a mechanical support. The dispensing unit is formed of the droplet formation unit and a heated tin reservoir. A piezo-resistive transducer (PZT) is used to generate droplets. The nozzles are interchangeable, such that the droplet size can be varied. The heated reservoir contains tin for 30hrs of continuous operation for 50µm droplets dispensed at 10kHz.

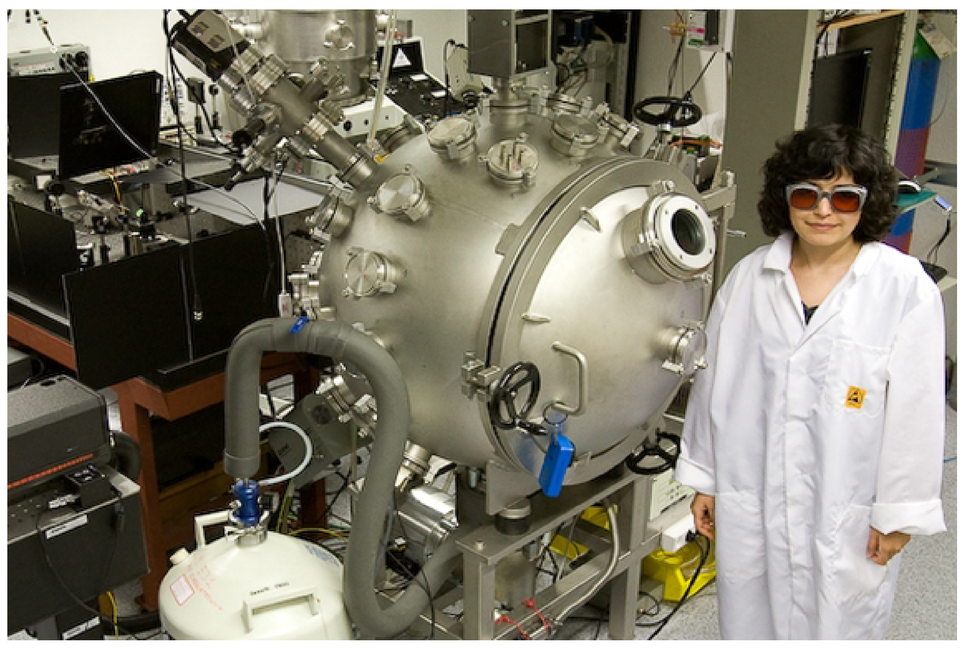


The mechanical support is thermally insulated from the dispensing unit. The goal is to limit the thermal expansion, hence the long-term drifts of the dispensing head. The motorization of the mechanical support is an additional counter-measure against long-term drifts.

System

The droplet generator plays a crucial role in terms of cost-of-ownership of the entire EUV source. The droplet quality, including droplet size and droplet train deflections, is a main driver for cost-of-ownership. Indeed high conversion efficiency and low plasma debris load can only be achieved withhigh droplet quality. For this reason, a major effort has been put into the development of the tin droplet generator.





Conclusions:

- Stable droplet generation with high reliability
- Droplet size and velocity can be varied over a large range
- Fast start-up time
- Thermally managed
- Active steering system
- Fulfilling source requirements

www.lec.ethz.ch

Contact: Bob Rollinger | Institut für Energietechnik, LEC | ETH Zürich, ML J 31 | Sonneggstrasse 3 | CH-8092 Zürich
Phone: +41 44 632 42 58 | Fax: +41 44 632 11 00 | E-Mail: rollinger@lec.mavt.ethz.ch